

# EXAMINING THE PROPERTIES OF JETS IN CORONAL HOLES

OWEN T. GAULLE, M. ADAMS, A.F. TENNANT

## Abstract

We examined both X-ray and Magnetic field data in order to determine if there is a correlation between emerging magnetic flux and the production of Coronal jets. It was proposed that emerging flux can be a trigger to a coronal jet. The jet is thought to be caused when local bipoles reconnect or when a region of magnetic polarity emerges through a uniform field. In total we studied 15 different jets that occurred over a two day period starting 2011-02-27 00:00:00 UTC and ending 2011-02-28 23:59:55 UTC. All of the jets were contained within a coronal hole that was centered on the disk. Of the 15 that we studied 6 were shown to have an increase of magnetic flux within one hour prior to the creation of the jet and 10 were within 3 hours before the event.

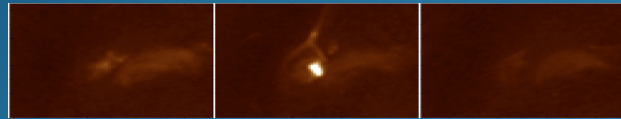


Figure 1: The evolution of a jet. These images span approximately 30 minutes and show how jets emerge and dissipate in a relatively quick manner.

## Introduction

Coronal jets are bursts of plasma that emanate from coronal holes and project upward from the surface. Figure 1 shows the evolution of a coronal jet. The observation of a jet that occurred with no emerging flux is what initiated this research.

## Discussion

When first identifying the jets we used AIA 193Å data to look for the events. The data was calibrated with Solarsoft processes. By making a movie of the region for a full 2 days we were able to note any brightening that were believed to be jets. We then zoomed in on the areas and noted the physical features of the suspected jets. The jets fell into 1 of 3 categories: Eiffel shaped, Lambda shaped, and Irregular<sup>1</sup>. The Eiffel shaped jets are equally balanced on both sides and relatively symmetrical. Lambda jets are lopsided in one direction and resemble a lowercase Greek lambda. Irregular jets were those that did not appear to have either of those features. These bright regions still appeared to have jetting activity, but the structures were rather messy and undefined.

We found a total of 15 jets over this two day period. Each of the jets with the corresponding location is shown in figure 2. Once the jets were discovered we calculated the velocity of each jet. We did this to see if there was any common link between the various jets in the coronal hole. Table 1 shows a range of velocities from 28 km/s up to 215 km/s as well as durations from 5 minutes to 55 minutes.

Jet No. (#)	Location (arcsec)	Start (UT)
1	-169, 504	00:37
2	-290, 377	00:57
3	-361, 406	02:39
4	-146, 334	03:30
5	-444, 512	05:55
6	-238, 316	06:06
7	-228, 499	17:42
8	-250, 206	25:42
9	-344, 563	26:08
10	-262, 491	26:41
11	-454, 542	31:33
12	-201, 294	33:03
13	-401, 524	35:59
14	-184, 550	36:38
15	-308, 446	46:26

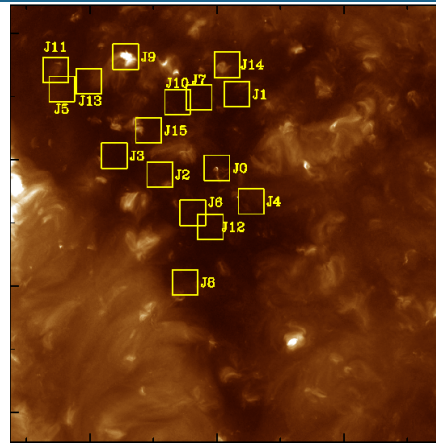


Figure 2: A table of each jet location along with the time that the jet appeared to be at its maximum.. Each jet's location is marked on the image. The jet labeled J0 was the initial jet that had no corresponding flux.

After calculating the velocity we began analyzing the full 2 day period of data. All analysis was done with Lextract. We squared the magnetic field because this can be used as a proxy for energy. We did this for a 25X25 arcsec region and plotted the B-squared value as a function of time for all 15 jet locations. The resulting data are listed in table 2. We looked for peaks in the magnetic field that occurred 6 hours before the jet. We also recorded the time and intensity for the peak that occurred during the full 2 day period. Occasionally the peak for the jet and the full duration coincided, but for the most part they were separated by long periods of time.

We did the same analysis for the 193Å. However, instead of squaring the values we simply summed the values in each 525 square arc-second region. From this we were able to attain a value of counts per second and plotted this as a function of time. We then fitted the peaks that were nearest to the time of the jet as well as the overall 2 day peaks. The results of this analysis are given in Table 1.

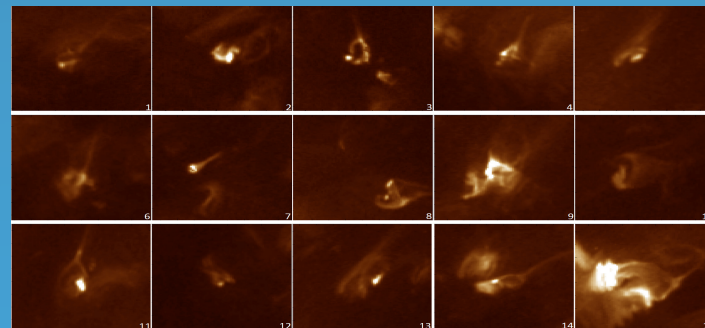


Figure 3: Each of the 15 jets that were studied. These images show the difference between the various types of jets. The numerical labels correspond to tables 1 & 2

Jet No. (#)	Duration (min)	Max Time (UT)	Jet Max (cts/s)	Velocity (km/s)	48 hr Max (UT)	48 hr Max (cts/s)
1	20	00:19	5.05 E+4	134	01:31	3.63 E+5
2	20	00:54	4.52 E+3	45	37:28	1.93 E+5
3	33	02:58	9.41 E+3	82	46:20	4.37 E+4
4	15	03:45	1.54 E+4	28	20:35	8.93 E+4
5	14	05:42	5.47 E+3	145	46:41	5.74 E+4
6	13	06:29	1.94 E+4	112	15:42	1.00 E+5
7	5	17:28	3.20 E+4	46	01:24	8.65 E+5
8	20	25:40	2.44 E+4	131	13:55	1.67 E+5
9	14	26:22	3.13 E+4	140	06:12	3.65 E+5
10	14	26:13	1.52 E+5	147	07:05	1.04 E+6
11	25	29:37	2.25 E+3	215	23:58	9.35 E+4
12	11	33:18	2.86 E+4	61	15:15	1.18 E+5
13	15	36:37	2.01 E+4	102	13:47	3.50 E+4
14	17	36:22	2.87 E+3	132	00:09	1.16 E+5
15	55	46:52	3.10 E+3	154	14:47	1.89 E+4

Table 1: shows the results of the 193 Å analysis. The 48 hr columns show the time and intensity of the peak for the full two days of data. The Max Time and Jet Time columns show the time and intensity of the peak located near the time of the jet.

Jet No. (#)	Δ T (hr)	Max Time (UT)	Max Value (Gauss-sec) <sup>2</sup>	Fraction Global Max	48 hr Max (UT)	48 Hr Max (Gauss-sec) <sup>2</sup>
1	0.25	00:18	2.32 E+16	0.343	11:42	1.29 E+17
2	0.18	00:46	5.62 E+16	0.076	19:15	4.24 E+17
3	0.18	02:28	1.65 E+16	0.058	14:36	1.47 E+17
4	0.40	03:06	1.80 E+16	0.079	08:23	1.95 E+17
5	3.46	02:27	9.24 E+17	1.001	03:08	8.48 E+17
6	0.50	05:36	4.37 E+16	0.458	33:04	7.38 E+16
7	2.40	15:18	9.43 E+16	0.401	40:32	1.32 E+17
8	4.08	21:37	1.24 E+17	0.217	45:51	6.44 E+17
9	2.48	23:39	2.72 E+16	0.685	17:09	2.87 E+16
10	0.85	25:50	3.26 E+16	1.208	21:31	5.43 E+16
11	6.21	25:20	1.14 E+17	0.112	06:10	9.89 E+17
12	1.58	31:28	1.06 E+17	0.789	42:14	8.84 E+16
13	2.06	33:55	9.04 E+16	0.291	26:45	2.08 E+17
14	6.03	30:36	1.38 E+17	1.280	31:51	1.89 E+17
15	4.95	41:29	8.97 E+16	1.107	40:57	1.00 E+17

Table 2: shows the results of the magnetic field analysis. The ΔT column indicates the amount of time before the jet that the peak occurs. The Fraction Global Max column shows how intense the peak near the jet is compared to the overall peak for the 2 day period. . The 48 hr columns show the time and intensity of the peak for the full two days of data.

## Results

When finally comparing the data sets we can show that for this set of data there was a moderate correlation between the jets and a possible emergence of flux. While the 6 hour time range we set was slightly arbitrary, it did show that these events occur relatively close together with 2/3<sup>rd</sup> of the events happening less than 3 hours apart.

## References

Nisticò, G., Bothmer, V., Patsourakos, S., Zimbardo, G.: 2010, Ann. Geophys. 28, 687.

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